N87-28789

TDA Progress Report 42-90 April–June 1987

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State Transition Storyboards: A Tool for Designing the Goldstone Solar System Radar Data Acquisition System User Interface Software

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Effective user interface design in software systems is a complex task that often takes place without adequate modeling tools. By combining state transition diagrams and the storyboard technique of filmmakers, State Transition Storyboards were developed to provide a detailed modeling technique for the Goldstone Solar System Radar Data Acquisition System human-machine interface. Illustrations are included with a description of the modeling technique.

I. Introduction

User interface design presents a unique set of problems to software engineering. After functional specifications have determined which parameters are to be available to the operator, human-machine interface design becomes basically a problem of presentation: having the right information, in the right place, at the right time. The presentation is a communication, usually complex, carefully sequenced, and often highly visual in nature.

This would seem to imply that the user interface should be the easiest part of a software system design to present, to communicate, to previsualize, and to specify. But this has not been the case. The design of the interface is often left either to last minute improvisation or to full prototyping. The prototyping strategy uses the interface itself as a model. In prototyping, there is no abstraction; instead, there are cycles modifications to the full product.

These approaches fail to consider two techniques th have been very useful in software development—step-by-st problem decomposition and the development of an extern graphical representation that abstracts important aspects the system. Stepwise refinement and top-down design [2] examples of problem decomposition and data flow diagra [3] are examples of graphical abstractions.

External representations are valuable because they ma design reviews (walk-throughs) possible. Members of t design team can then examine and comment on the desig adding new ideas and directing attention to oversights bef specifications are written and the design is committed to co

In most instances, a diagram is more easily modified than a software prototype. The model also forms a record of the evolution of the design as problem decomposition proceeds from a high-level sketch to a final detailed specification.

Problem decomposition in the user interface has a different character than successive refinement in structured programming. For example, if the user interface is indeed another type of human communication, the problem will decompose into the familiar phases of communicating ideas: every interface would be expected to comprise an introduction or orientation, a central functional unit with no more than seven major phases [4], and a conclusion or orderly exit. The orientation might decompose into an introduction screen and a set of "help" screens. Then the general content of each screen can be sketched and later refined to specify string lengths and locations.

State Transition Storyboards were created to provide the Goldstone Solar System Radar (GSSR) Data Acquisition software design team with a modeling tool for developing and specifying the human-machine interface. The technique comprises two ideas. The Yourdon methodology [3] recommends thinking of the user interface as a finite state machine; state transition diagrams describe transitions triggered by user actions. Software designer Paul Heckel [5] describes the creation of a user interface as a communications craft and recommends the storyboarding technique of filmmaking for describing the appearance of the user interface in a sequential manner. Combining these ideas allows a graphical abstraction of the interface presentation as it responds to the operator.

II. Description

State Transition Storyboards are directed graphs composed of nodes, edges, and edge labels. The shape and content of a node abstracts the screen presentation. Edges indicate the allowable transitions that may take place from that state to other states. Edge labels carry two types of information: (1) the action that causes a transition is summarized above a horizontal line and (2) the steps that effect the transition can be listed below the line. These diagrams are visual in nature, like much of the user interface itself. Figure 1 is given as an illustration.

Transitions can return immediately to the same state. For example, pressing an arrow key on a terminal keyboard might cause a "control G" (bell) and a return to the same screen state. Symbols or icons can be used to represent states that are accessed by many transitions and are therefore graphically difficult to connect. As an example, "help" or information screens are usually accessible from many states. A small labeled screen adjacent to a normal node is used in the manner of an "off-page connector" to indicate that transitions can occur between these states. Figure 2 illustrates these situations.

III. Summary

State Transition Storyboards allow a software designer to sketch and revise interface design ideas quickly to the level of specificity required by the design at that moment. Then, given any state as a precondition and a user action or system update, the postcondition can be determined immediately. Information contained in these diagrams can be easily converted to state transition tables in software for accurate final prototyping. The GSSR Data Acquisition software team is currently exploring extensions to this idea. A draft version of the Goldstone Solar System Radar Data Acquisition System User Interface plans, using the State Transition Storyboard technique, is given in Fig. 3. (The GSSR Data Acquisition System is described in *TDA Progress Report 42-77* [1].)

References

[1] L. J. Deutsch, R. F. Jurgens, and S. S. Brokl, "Goldstone R/D High Speed Data Acquisition System," *TDA Progress Report 42-77*, vol. January–March 1984, pp. 87–96, Jet Propulsion Laboratory, Pasadena, California, May 15, 1984.

[2] S. Alagic and M. A. Arbib, *The Design of Well-Structured and Correct Programs*. New York, New York: Springer-Verlag, 1978.

[3] P. T. Ward and S. J. Mellor, *Structured Development for Real-Time Systems*. New York, New York: Yourdon Press, 1985.

[4] G. A. Miller, "The Magical Number Seven Plus or Minus Two: Some Limits on Our Capacity for Processing Information," *Psychological Review*, vol. 63, no. 2, pp. 81–97, 1956.

[5] P. Heckel, *The Elements of Friendly Software Design*. New York, New York: Warner Books, Inc., 1984.

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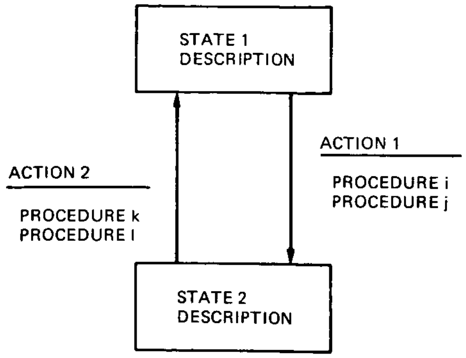

Fig. 1. Basic diagram elements: edges, nodes, and edge labels

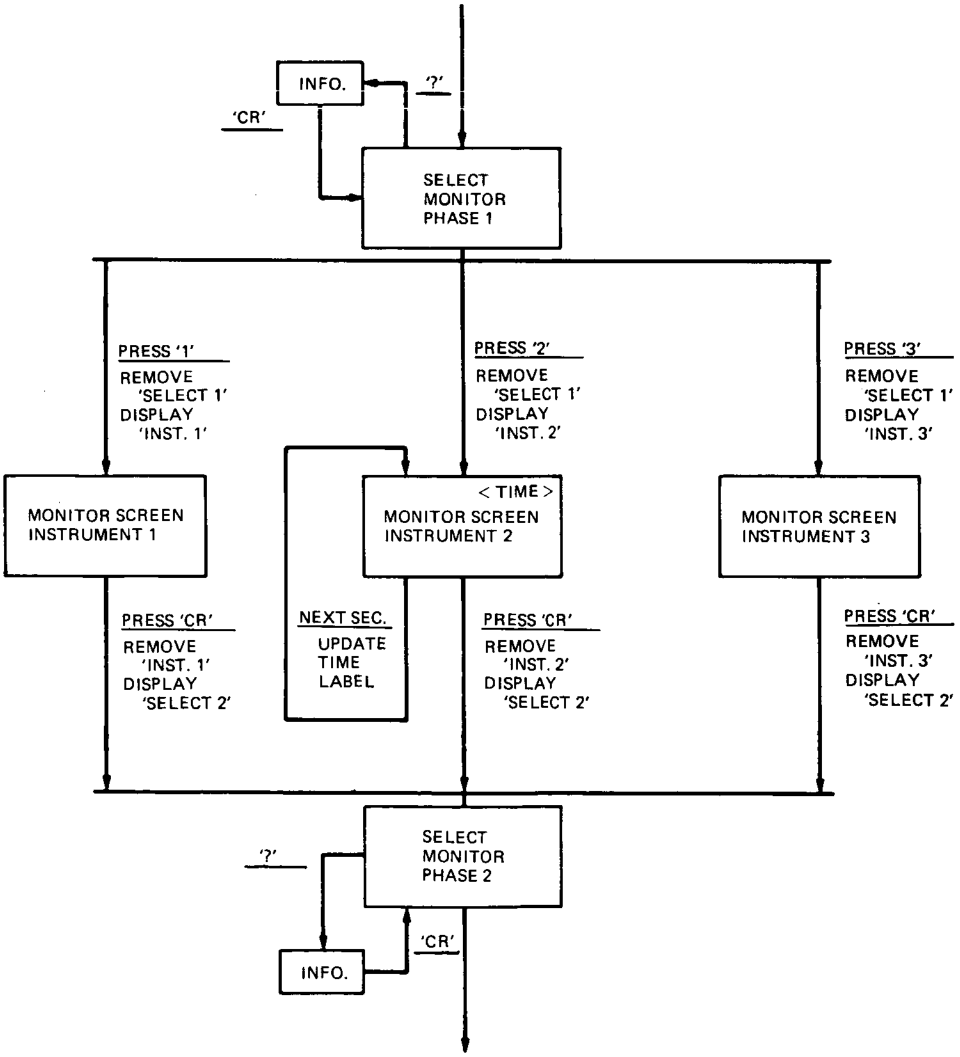

Fig. 2. Special diagramming situations

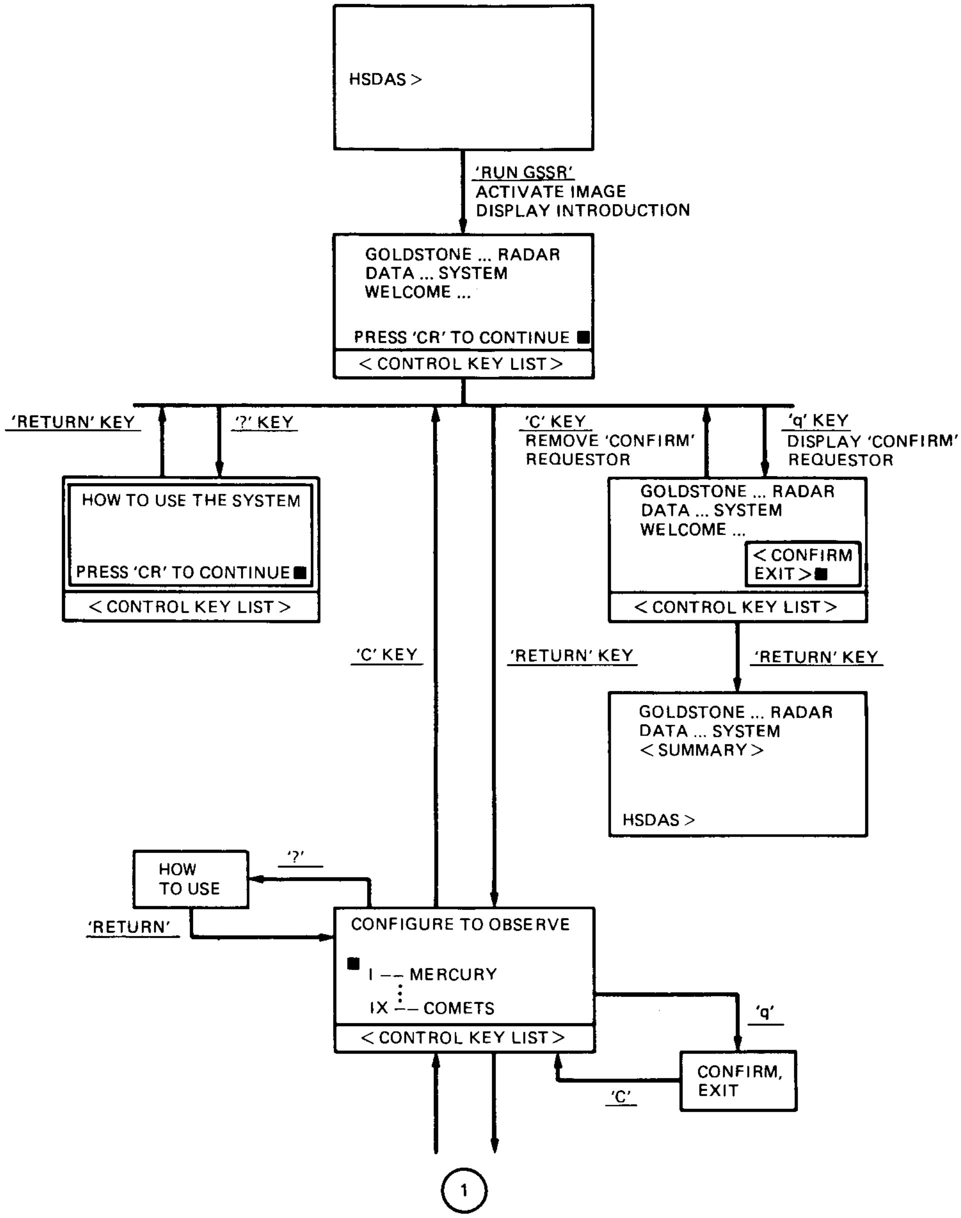

Fig. 3. Goldstone Solar System Radar Data Acquisition System User Interface (draft)

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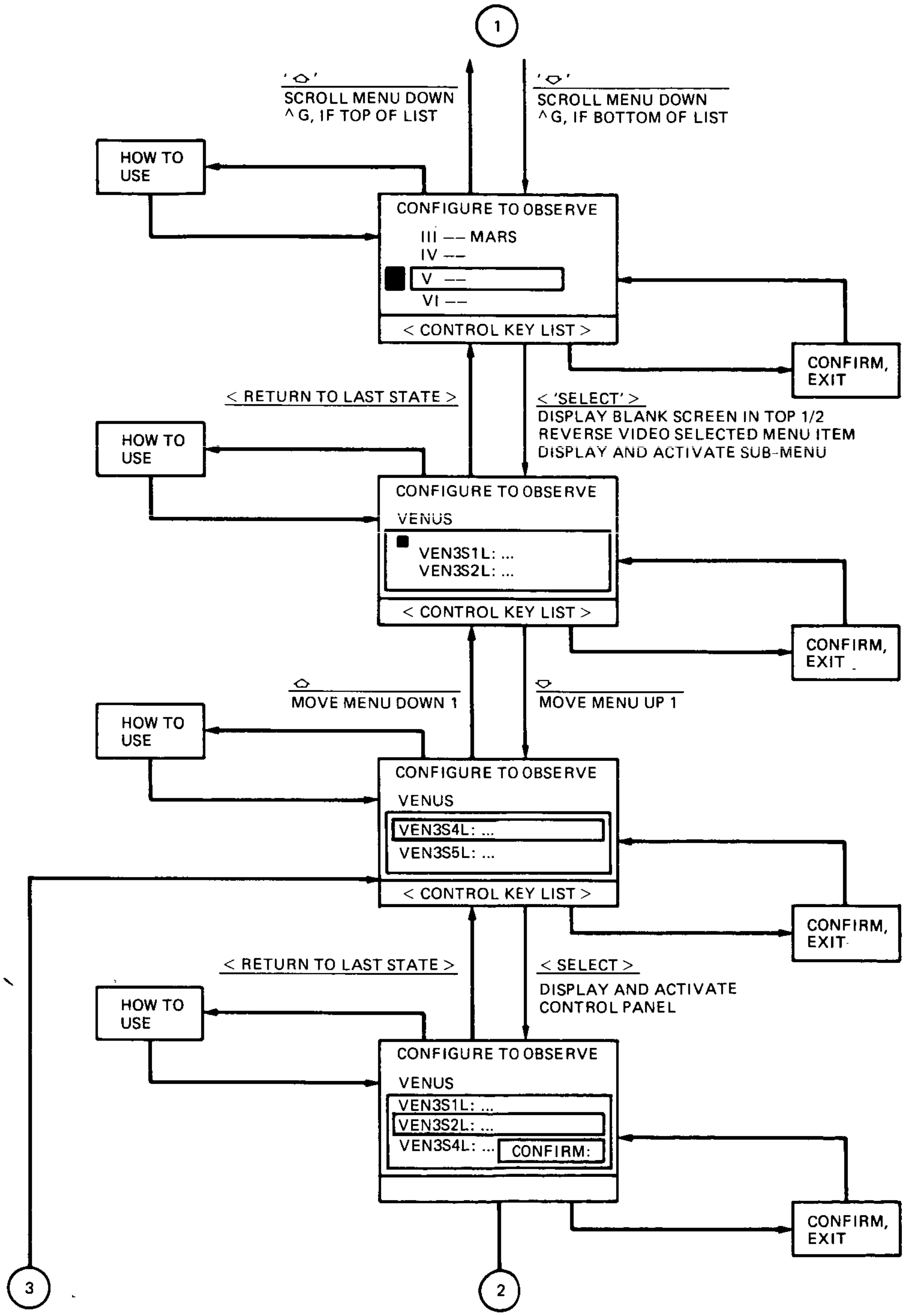


Fig. 3 (contd)

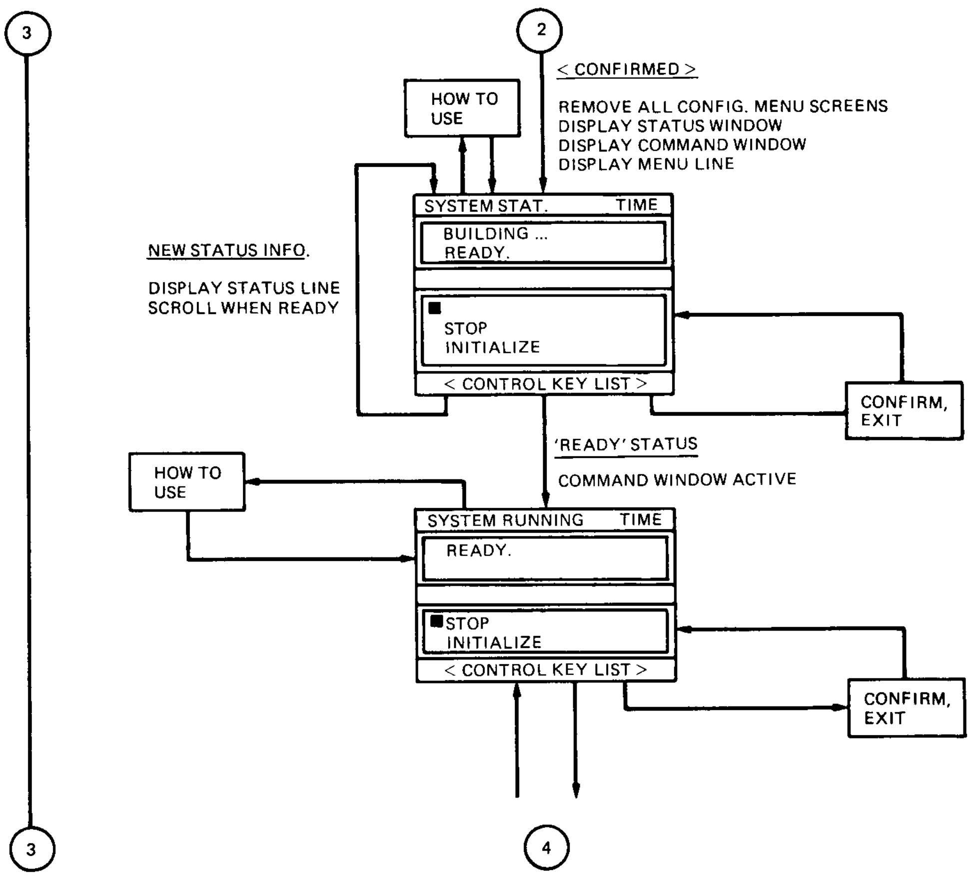
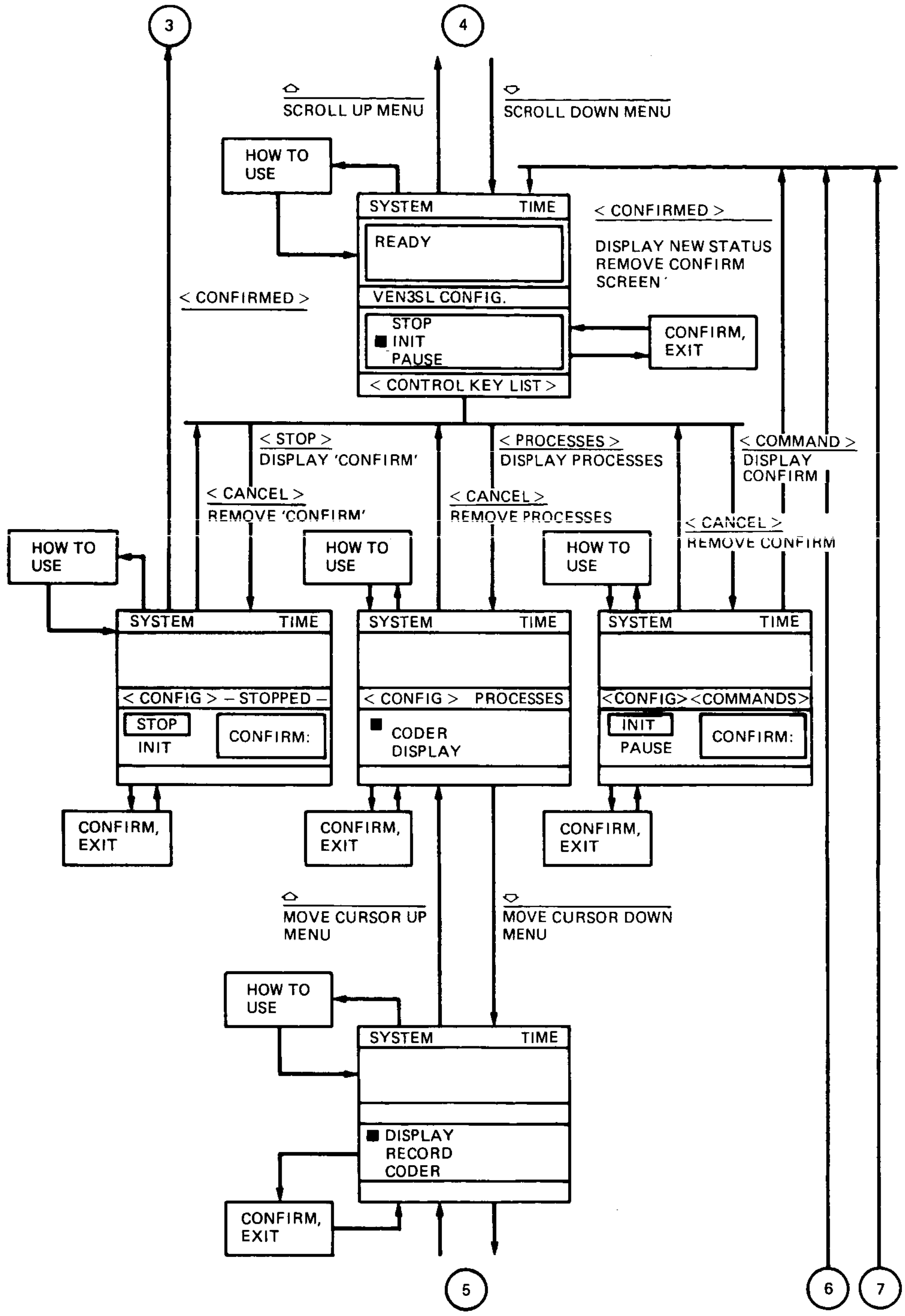

3
2
< CONFIRMED >
REMOVE ALL CONFIG. MENU SCREENS
DISPLAY STATUS WINDOW
DISPLAY COMMAND WINDOW
DISPLAY MENU LINE
HOW TO USE
SYSTEM STAT. TIME
BUILDING ...
READY.
NEW STATUS INFO.
DISPLAY STATUS LINE
SCROLL WHEN READY
STOP
INITIALIZE
< CONTROL KEY LIST >
CONFIRM, EXIT
'READY' STATUS
COMMAND WINDOW ACTIVE
HOW TO USE
SYSTEM RUNNING TIME
READY.
STOP
INITIALIZE
< CONTROL KEY LIST >
CONFIRM, EXIT
3
4

Fig. 3 (contd)


3
4
SCROLL UP MENU
SCROLL DOWN MENU
HOW TO USE
SYSTEM TIME
READY
VEN3SL CONFIG.
STOP
INIT
PAUSE
< CONTROL KEY LIST >
< CONFIRMED >
DISPLAY NEW STATUS
REMOVE CONFIRM
SCREEN
< CONFIRMED >
CONFIRM,
EXIT
< STOP >
DISPLAY 'CONFIRM'
< CANCEL >
REMOVE 'CONFIRM'
< PROCESSES >
DISPLAY PROCESSES
< CANCEL >
REMOVE PROCESSES
< COMMAND >
DISPLAY
CONFIRM
< CANCEL >
REMOVE CONFIRM
HOW TO USE
HOW TO USE
HOW TO USE
SYSTEM TIME
< CONFIG > – STOPPED –
STOP
INIT
CONFIRM:
SYSTEM TIME
< CONFIG > PROCESSES
CODER
DISPLAY
SYSTEM TIME
<CONFIG><COMMANDS>
INIT
PAUSE
CONFIRM:
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MOVE CURSOR UP
MENU
MOVE CURSOR DOWN
MENU
HOW TO USE
SYSTEM TIME
DISPLAY
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CODER
CONFIRM,
EXIT
5
6
7

Fig. 3 (contd)

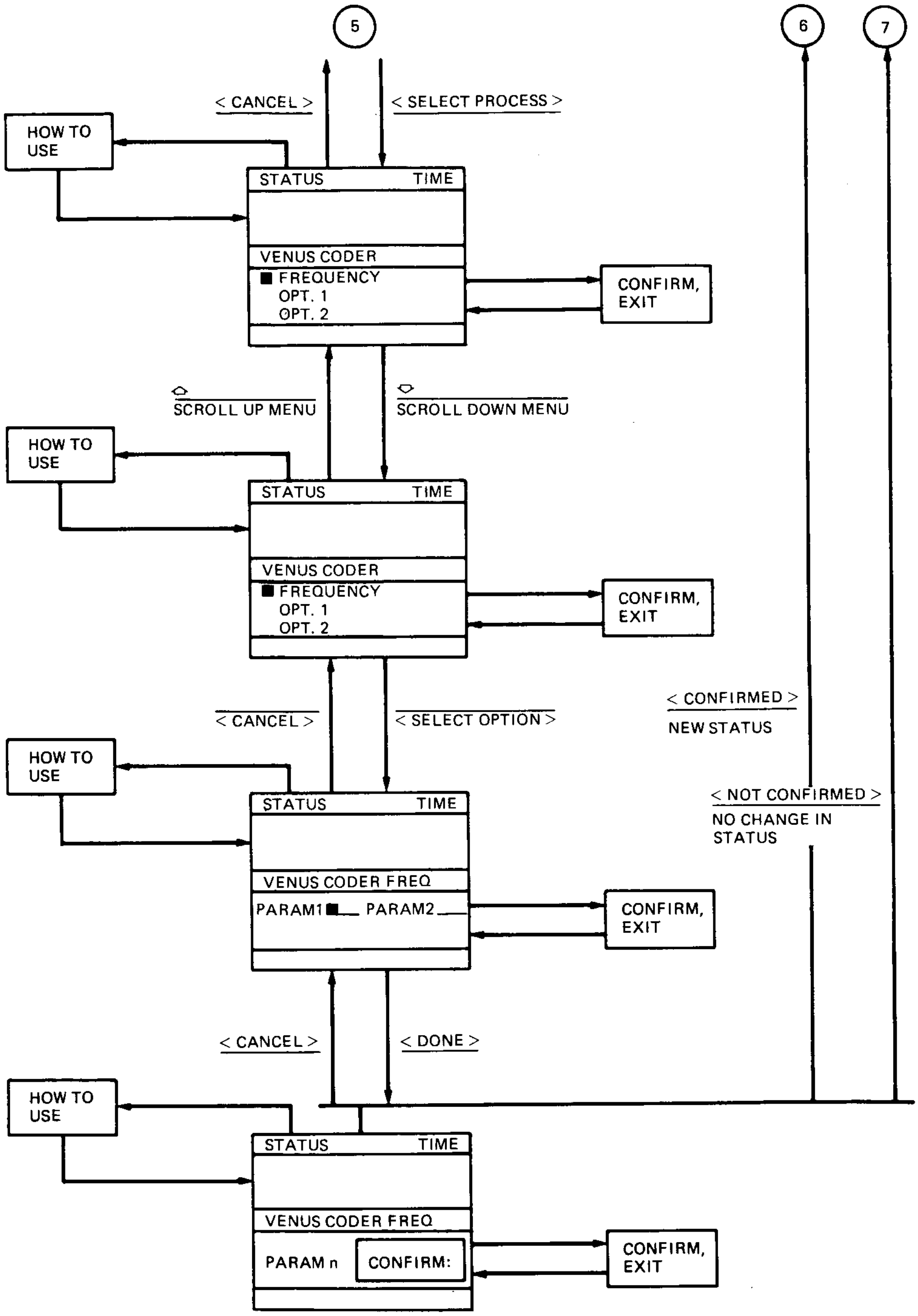
5
6
7
< CANCEL >
< SELECT PROCESS >
HOW TO USE
STATUS TIME
VENUS CODER
■ FREQUENCY
OPT. 1
OPT. 2
CONFIRM, EXIT
SCROLL UP MENU
SCROLL DOWN MENU
HOW TO USE
STATUS TIME
VENUS CODER
■ FREQUENCY
OPT. 1
OPT. 2
CONFIRM, EXIT
< CANCEL >
< SELECT OPTION >
< CONFIRMED >
NEW STATUS
HOW TO USE
STATUS TIME
VENUS CODER FREQ
PARAM1 ■__ PARAM2__
CONFIRM, EXIT
< NOT CONFIRMED >
NO CHANGE IN STATUS
< CANCEL >
< DONE >
HOW TO USE
STATUS TIME
VENUS CODER FREQ
PARAM n
CONFIRM:
CONFIRM, EXIT

Fig. 3 (contd)